Preprint ЕФИ-829(56)-85

ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

Sh.S. EREMYAN, V.M. ZHAMKOCHYAN

# ON TOTAL CROSS SECTIONS AND SLOPES AT SUPERHIGH ENERGIES

ЦНИИатоминформ

ЕРЕВАН-1985

Препринт ЕФИ-829(56)-85

Ш.С.ЕРЕМЯН, В.М.ЖАМКОЧЯН

# О ПОЛНЫХ СЕЧЕНИЯХ И НАКЛОНАХ ПРИ СВЕРХВЫСОКИХ ЭНЕРГИЯХ

Проведен сравнительный анализ адрон-адронных взаимодействий в теориях с критическим и надкритическим померонами. Показано, что основные характеристики бинарных взаимодействий в обеих теориях практически совпадают друг с другом во всем интервале достижимых энергий. Дан также анализ характеристик адрон-ядерных взаимодействий в рамках редженной теории поля с критическим и надкритическим померонами и теории многократного рассеяния. Полученные результаты согласуются с существующими экспериментальными данными по протон-ядерным взаимодействиям при сверхвысоких энергиях.

Ереванский физический институт

Ереван 1985

Preprint ЕФИ-829(56)-85

Sh.S. EREMYAN. V.M. ZHAMKOCHYAN

# ON TOTAL CROSS SECTIONS AND SLOPES AT SUPERHIGH ENERGIES

A comparative analysis of hadron-hadron interactions in theories with critical and supercritical pomerons is carried out. The main characteristics of binary interactions in both theories are shown practically to coincide to each other in the whole range of accessible energies. Also an analysis of characteristics of hadron-nuclei interactions is given in the framework of Reggeon field theory with critical and supercritical pomerons and multiple scattering theory. The results obtained agree with available experimental data on proton-nuclei interactions at superhigh energies.

Yerevan Physics Institute

Yerevan 1985

## 1. Introduction.

At present, there exist two at first sight alternative theoretical conceptions concerned with a description of interaction processes of high and superhigh energy hadrons. One of them is the theory with renormgroup critical pomeron (RCP) [1-4] ( $\alpha_P(0) \equiv 1$ ), the other - with supercritical ( $\alpha_P(0) \equiv 1$ ) - froissaron [5-7] .

Both theories are based on quark-gluon picture of strong interactions which allows one to reach a substantial progress in understanding the hadronic interactions at large distances where the QCD perturbation theory is inapplicable (see, e.g. [6] ).

Together with P-pole exchange (cylindrical diagram), both theories take into account also $n$-pomeron branchings which in the case with RCP make a large contribution to the pre-asymptotic energy region, while in the case with froissaron they contribute essentially to the asymptotic energy region.

The present work is concerned with a comparison of the both models to each other as well as to experimental data at medium, high and superhigh energies. At energies more than $E_{lab} > 10^{11}$ GeV the contributions of the hard processes to total cross sections will most probably dominate over the soft ones and both models will become practically inapplicable. However such energies will hardly be achieved till the end of the current millennium: therefore our investigation will be restricted to the energy region $\xi \leqslant 25$ ($\xi = \ln S/S_0$), where the contribution of the hard processes may apparently be neglected so far.

Our optimism apropos of the idea that one and the same theory can be applicable in a giant energy range $10 \leqslant E_{lab} \leqslant 10^{10}$ GeV is explained by the fact that $\xi$ which varies only from 2.5 to 25 is a characteristic parameter of theory rather than E. Our assertion is that theory which is applicable at $\xi \approx 10$ must be applicable at $\xi \approx 25$ too.

The comparison between the two models shows that both RCP and froissaron describe almost equally well the whole at present existing set of experimental data on hadron-hadron interactions, although the theory with RCP looks somewhat more preferable. Essential differences in the predictions begin to manifest at $\xi > 16$, but in case of hadron-hadron interactions they are not of principal nature, and some variation in the model parameters will allow one to make both theories coinciding at least up to $\xi \approx 22$, and this will entirely overlap a practically accessible energy region. The principal differences between these theories begin to display only in the consideration of hadron-nuclear interactions which will just serve as a good test for choosing a correct theory.

Recently, there were published new results [8-10] on experimental study of inelastic cross sections of cosmic energy protons interaction with the air atomic nuclei which overlap a sufficiently wide energy region up to $\xi \lesssim 22$. Therefore of great interest is the comparison of these models in cosmic energy region, which Sect.3 of the present work is concerned with.

In Sect.4 we carry out a comparison between the models predictions and the experimental data for hadron-hadron interactions. All possible characteristics of elastic scattering are considered: total cross sections, slopes of the diffraction cone, elastic and inelastic cross sections, etc.

Sect.5 deals with theoretical predictions for hadron-nuclei interactions· their comparison with experimental data is carried out.

In Sect.6 we show possibilities existing in each of the models to improve their agreement with the experiment.

At the end of the work we give a table of predictions for the future accelerators.

## 2. Elastic Scattering Amplitude.

### a) Renormgroup Critical Pomeron - RCP.

Consider firstly the theory with renormgroup critical pomeron. It is based on Reggeon field theory (RFT) with account of pomeron production thresholds. The RFT was exhaustingly considered in Refs [1,11,12] . Obtained in these works pomeron Green function proved to be very suitable for theoretical description of hadronic interactions at superhigh energies and was used [2-4] for description of total cross sections, slopes of the diffraction cone, differential cross sections and other characteristics of elastic hadron-nuclei and hadron-hadron interactions.

It was shown [1,4] that at low energies, RCP smoothly turns into Reggeon perturbation theory which describes well all features of the rich experimental material existing at low and medium energies (see, e.g. [13] ).

The main difference between RCP and other field theories (e.g. QED or QCD) is that at any finite energy a finite number of perturbation theory diagrams contribute to scattering amplitude. This is due to the fact that there exists a threshold energy below which pomeron doesn't exist. Hence we have a perturbation theory over three-pomeron coupling constant $\tau_0$ , in which the number of diagrams at any given energy is limited being determined by value of energy. With increasing energy, the number of diagrams begins to grow in an avalanche-like way, and the perturbation theory becomes practically inapplicable; however owing to this latter, it becomes possible to use the RCP obtained in Ref. [1] .

As was shown in Ref. [11] , the "bare" value of pomeron intercept must exceed unity by some value $|\Delta_{oc}|$ ; then, after renormalization, the intercept value becomes equal to unity. This case just corresponds to critical pomeron. In case when the intercept "bare" value is above $1 + |\Delta_{oc}|$ , the renormalization cannot decrease the intercept down to unity and this corresponds to supercritical pomeron. When the intercept "bare" value $\alpha_o < 1 + |\Delta_{oc}|$ , the renormalized intercept lies below unity and corresponds to subcritical pomeron case. The experimental data analysis shows that the version with $\alpha_o < 1 + |\Delta_{oc}|$ does not correspond to the experiment data. So the versions with $\alpha_o \geqslant 1 + |\Delta_{oc}|$ remain. At medium and high energies the pole amplitude in both versions behaves as $S^{\Delta}$ . At $\alpha_o = 1 + |\Delta_{oc}|$ when $S \to \infty$ , $\Delta \to 0$ , the amplitude turns to the critical pomeron regime and behaves as $\sim \xi^{0,277}$ . When $\alpha_o > 1 + |\Delta_{oc}|$ at $S \to \infty$ , the amplitude turns to the froissaron regime $\sim \xi^2$. I.e. the differences between the models start to display only at very high energies $\xi \geqslant 16$. In the case of critical pomeron $\Delta_{oc}$-critical can be obtained from the following equation [1]

$$\Delta_{oc} = -\frac{\tau_o^2}{16\pi\alpha'_o}\,\frac{e^{-3\xi_o\Delta_{oc}}}{1-\xi_o\Delta_{oc}}\left\{e^{2[1+\xi_o\Delta_{oc}]}Ei[-2(1+\xi_o\Delta_{oc})] - e^{-4\xi_o\Delta_{oc}}Ei(-4\xi_o\Delta_{oc})\right\}.$$

From the experimental data analysis [13] we have: $\tau_o^2 = 0.36 \pm 0.1$ and $\xi_o = 2.5 \pm 0.5$, this giving $|\Delta_{oc}| = 0.018 \pm 0.002$.

The methods for obtaining the amplitude with a single RCP were often discussed being referred to in many works [1-4] ; therefore we shall give here only final results without going into details. The imaginary part of the amplitude with a single renormalized renormgroup critical pomeron exchange has the following form:

$$\operatorname{Im} M^{(1)}(\xi, K^2) = \beta(\xi) e^{-x a(\xi)} F_2(\xi, x), \qquad (1)$$

where

$$\beta(\xi) = g_1 g_2 \cdot 0{,}4734\, \xi^{0,277} F_1(\xi),$$

$$x = 0{,}407\, \xi^{1,139} K^2 ; \quad \xi = \ln\left(\frac{S}{S_0}\right) ; \quad K^2 = -t , \qquad (2)$$

$x$- is a new scale variable, corresponding to transferred momentum, $g_1, g_2$ are vertex functions of pomeron-particle coupling. $F_1(\xi)$ , $F_2(\xi, x)$ and $a(\xi)$ are scale functions determining the amplitude energy and t-dependence. All these functions were theoretically defined and calculated in Ref. [1] .

In the low-energy region we have $F_1(\xi) \sim \xi^{-0,277} S^{\Delta oc}$ and $a(\xi) \sim \xi^{-1,139}(R^2 + \alpha'_0 \xi)$ , i.e. amplitude (1) takes its usual pole form. At high energies the scale functions have a very complex structure which was calculated in Ref. [1] .

In low- and high-energy region an essential contribution is made by amplitudes with RCP re-scattering on each other. In the region of asymptotically high energies the contributions of the branchings die out and the scattering amplitude enters the asymptotic regime $\sim \xi^{0,277}$ . But in the region of practically accessible energies we are interested in, the contribution of the branchings is very large and provides a high rate of total cross sections growth, of the order of $\xi^2$ .

So long as a highly essential contribution to RCP is made by the highest-order branchings, then to apply the method of exact summation of quasi-eikonal series determined in Ref. [14] rather than a usual quasi-eikonal model used in Refs [2,3] would be much more correct.

The diffraction excitation of hadronic states with small masses $M \lesssim (2 \div 3)$ GeV is approximately taken into account along with elastic re-scatterings in quasi-eikonal models. In a usual quasi-eikonal model this account is carried out correctly up to the fourth-order branching; as to the highest-order ones, they are calculated with large errors. However, when the value of the pole eikonal

$$Z \sim \frac{\beta(\xi)}{A(\xi)}, \qquad \text{where} \qquad A(\xi) = \frac{X}{K^2}\,a(\xi)$$

is not too large, the highest branchings contributions are small and a usual quasi-eikonal model can be used. When $Z$ is large, one should apply the method of quasi-eikonal series exact summation which takes into account the highest branchings contributions correctly. In RCP at high energies $Z$ decreases as $\xi^{-0,862}$ and the usual quasi-eikonal model becomes applicable already at $\xi > 18$. In the supercritical pomeron theory an inverse situation can be observed: $Z$ grows with increasing energy and at superhigh energies the usual quasi-eikonal model becomes inapplicable.

The use of the method of quasi-eikonal series exact summation allowed us to increase considerably the pomeron-particle coupling constant $g^2$. Instead of 6.71 in Refs [2-4,13], it took here the value

$$g^2 = 10.8 \pm 0.05\ (\text{GeV/c})^{-2} \tag{3}$$

allowing to increase sharply the rate of growth of total cross sections at superhigh energies and leaving the region of low and high energies unchanged. The resulting elastic scattering amplitude describes well all existing experimental data on total cross sections, slopes of the diffraction cone, differential cross sections and other characteristics of hadron elastic interactions in a wide energy range from the threshold $\xi_o = 2.5$ ($E \approx 10$ GeV) up to SPS-collider energy $\xi = 12.58$ as well as gives predictions for all practically accessible energies.

b) Supercritical Pomeron - Froissaron.

We have taken the form of the scattering amplitude in the supercritical pomeron theory from Ref.[6] . The total cross section and slope of the diffraction cone at $t=0$ in the usual quasi-eikonal model are determined as follows:

$$\sigma^{tot}(\xi) = \sigma_P f(z/2) , \qquad (4)$$

$$B(\xi, \kappa^2 = 0) = \frac{2\sigma_P \lambda_P}{\sigma^{tot}(\xi)} f_1(z/2), \qquad (5)$$

where

$$\lambda_P = R^2 + \alpha' \xi$$

and

$$z = \frac{2C\gamma_P}{\lambda_P} e^{\xi\Delta} \qquad (6)$$

is the pole quasi-eikonal defining the relative value of successive rescatterings, $\sigma_P = 8\pi\gamma_P e^{\xi\Delta}$ , parameters $\gamma_P = g_1(0) g_2(0)$ and $R^2 = R_1^2 + R_2^2$ characterize the hadron-pomeron coupling vertex, and the shower amplification coefficient $C$ has the form:

$$C = 1 + \frac{\sigma^{DD}}{\sigma^{el}} , \qquad (7)$$

where $\sigma^{\mathcal{DD}}$ is total cross section of the diffraction dissociation.

The data processing of the experiment with $\sigma^{tot}$ and $d\sigma/dt$ has given for $pp$ and $\bar{p}p$ scattering the following parameter values [5]:

$$\gamma_p = 3.64\ (\mathrm{GeV/c})^{-2}\ ; \quad R^2 = 3.56\ (\mathrm{GeV/c})^{-2}\ ; \qquad C \simeq 1.5\ ;$$

$$\Delta = \alpha_p(0) - 1 = 0.07 \pm 0.03\ ; \quad \alpha'_p = 0.25 \pm 0.1\ (\mathrm{GeV/c})^{-2}. \tag{8}$$

Recently, a new set of parameters was obtained:

$$\gamma_p = 2.4 \pm 0.03\ ; \qquad R^2 = 3.30 \pm 0.02$$

$$\Delta = 0.12 \pm 0.02\ ; \qquad \alpha'_p = 0.22 \pm 0.02\ . \tag{8a}$$

The calculations were performed for the both sets of parameters. The set (8a) provides a better agreement with the experiment.

The cross section $\sigma_o$ of the elastic scattering diffraction processes and diffraction dissociation in the usual quasi-eikonal model is written in the form:

$$\sigma_o(\xi) = \sigma_p[f(z/2) - f(z)]; \quad \sigma^{el} = \sigma_o(\xi)/C;$$

$$\sigma^{\mathcal{DD}} = \frac{C-1}{C}\sigma_o(\xi); \; f(z) = \sum_{\nu=1}^{\infty}\frac{(-z)^{\nu-1}}{\nu\cdot\nu!}; \; f_1(z) = \sum_{\nu=1}^{\infty}\frac{(-z)^{\nu-1}}{\nu^2\cdot\nu!} \tag{9}$$

At $z \to \infty$ when $z \gg 1$ and $f(z/2) \simeq \ln(\gamma_E z/2)/(z/2)$, where $\gamma_E = 0.577$ is the Euler constant; the interaction total cross section defined in (4) will grow as $\xi^2$

$$\sigma^{tot} \simeq \frac{8\pi}{C}\lambda_p\left(\xi\Delta + \ln\frac{C\gamma_p\gamma_E}{\lambda_p}\right) \approx \frac{8\pi\alpha'_p\Delta}{C}\xi^2,$$

i.e. reaches the froissaron regime.

It should be noted again that at $\Xi \gg 1$ the usual quasi-eikonal formulae (4) and (9) become inapplicable, so the calculations will have to be carried out by the formulae of the method of quasi-eikonal series exact summation from Ref.[14] ; hence the possibility of achievement of froissaoon limit becomes not so obvious. Besides, formulae (4)-(9) are obtained taking into account only non-amplified RCP diagrams. At superhigh energies the contribution of amplified diagrams becomes rather essential despite even relative smallness of three-pomeron constant $r$ . The account of all these factors must change essentially pre-asymptotic behaviour of theory with supercritical pomeron.

3. Hadron-Nuclei Interactions.

In the energy region $10 < \xi < 20$ we are interested in, there exist only measurements of $\sigma^{prod}_{p-air}$ -inelastic cross section of proton-nuclei interaction on the air atomic nuclei, obtained from the cosmic-ray experiments [8-10] . Despite the fact that these data contain monstrous errors, nevertheless they indicate the general tendency of the cross section behavior and can help us to make a choice of a theory describing the experimental situation more adequately. For that, one should first describe the cross section $\sigma^{prod}_{p-air}$ itself, and second, extract from experimental data on the air atomic nuclei the total cross sections of proton-proton scattering, $\sigma^{tot}_{pp}$ , in both theoretical models. The procedure of this extraction was described in detail in Refs [2,3] , so we shall present here only its basic moments.

Using the formalism of multiple scattering theory [15] with a correct account of increase of pN-interaction diffraction cones slopes, one can obtain the following expression for inelastic cross section of proton-nuclei interaction [2] :

$$\sigma^{(0)}_{prod} = 2\pi\int_0^\infty B\,dB\Big[1-\exp_A\Big\{-\frac{A\sigma^{tot}_{PN}}{\pi(2\beta+R^2)}\exp\Big(-\frac{B^2}{2\beta+R^2}\Big)+ \tag{10}$$

$$+\frac{A\sigma^{el}_{PN}}{\pi\,(\beta^2+R^2)}\exp\Big(-\frac{B^2}{\beta+R^2}\Big)\Big\}\Big],$$

where

$$\exp_A\{x\} = \Big(1+\frac{x}{A}\Big)^A.$$

For deriving (11) we have used the Gaussian parametrization for one-particle nuclear density [16] :

$$\rho(r) = \frac{A}{(\sqrt{\pi}R)^3}\, e^{-\frac{r^2}{R}}, \tag{11}$$

this being quite justified for the air atomic nuclei ( $\bar{A}$ = 14.4).

While calculating the cross sections under consideration, we carried out also the account of the correction $\Delta\sigma^{inel}_{prod}$ connected with inelastic channels (diffraction dissociation) [17] . Besides that, in the experimental data analysis we took into account the specificity of the corresponding cosmic-ray experiments leading to some underestimation of measured cross sections by the quantity of $\Delta\sigma^{air}$ (according to [17] $\Delta\sigma^{air}$ = 15 + 16 mb).

**4. Comparison with the Hadron-Hadron Interaction Experiment.**

Before proceeding to a comparison of theoretical predictions with experimental data, we'd like to make some preliminary remarks. Note that at energies above 1000 GeV the characteristics of $pp$ and $\bar{p}p$ -interactions practically coincide. Therefore we shall compare in what follows the data on $\bar{p}p$ -interaction at SPS-collider energies to those on $pp$ -interactions at lower energies. All experimental data used in the present paper are taken from

Refs [18-28] . In all figures given in this paper three curves are plotted - solid one refers to the RCP theory, dash-dotted ones - to the model with supercritical pomeron, with sets of parameters (8) and (8a).

a) Total Cross Sections $\sigma_{pp}^{tot}$ .

Fig.1 presents total cross sections of $pp$-interaction at $E_{lab}$ from 10 to $10^{12}$ GeV. Both models describe equally well the region of medium and high energies and practically coincide up to $\xi \leqslant 15$.

The cross section given by critical pomeron first grows very quickly: $\sim \xi^2$ ; at SPS-collider energy ( $\xi = 12.58$) it reaches the value of 62.2 mb; the experimental value is 61.9±1.5 mb. At $\xi \geqslant 15$ ($E_{lab} \geqslant 10^7$ GeV) the growth rate begins to slow down gradually turning then to asymptotical one $\sim \xi^{0,277}$.

In the froissaron case the best agreement with experimental data is provided by the set of parameters (8a). The cross section at this set of parameters grows quickly from the very beginning and achieves 62.4 mb at the collider energy. At $\xi \geqslant 15$ it begins to exceed the cross section given by RCP and turns to its asymptotic regime $\sim \xi^2$. The parameters set (8) provides much slower growth at $\xi = 12.58$; the cross section in this case is 57.2 mb. Entering to the asymptotic regime occurs at $\xi \geqslant 25$ ($E_{lab} \geqslant 10^{11}$GeV).

In the region of comparatively low energies ( $\xi < 15$) the cross section in the froissaron theory behaves as $e^{\xi\Delta}$ , while in the RCP theory as $\xi^2$ . With increasing energy froissaron transits to froissaron regime $\sim \xi^2$ , while RCP into pole regime $\sim \xi^{0.277}$. The essential difference in the cross sections given by these models appears only at $\xi > 20$ ($E_{lab} > 10^9$ GeV). I.e. total cross sections cannot serve as a test for choosing a correct model. Note that at $\xi > 15$ the quasi-eikonal formulae (4)-(9) for froissaron become inapplicable.

b) The Slope of the Diffraction Cone $b(\xi)$ at $-t < 0.1$.

Fig.2 presents the slope of the pp-interaction diffraction cone at $-t < 0.1$ GeV$^2$. One can see that both models describe well the experimentally observed growth of slope $B(\xi)$ though both curves with froissaron at $\xi \approx 12$ lie somewhat higher than experimental points. The new, more precise data of SPS-collider give the value $15.2 \pm 0.2$ (GeV/c)$^{-2}$. The theory with RCP at this energy gives 15.7, while with froissaron $15.6 \div 16.4$ (GeV/c)$^{-2}$. Ibidem is shown also the corridor of theoretical errors due mainly to the fact that the value of the pomeron "bare" slope $\alpha'_P(0)$ is defined insufficiently well. In RCP, from the comparison with experiment at low energies, we have $\alpha'_P(0) = 0.4 \div 0.5$ (GeV/c)$^{-2}$. The corridor upper boundary refers to 0.5, while the lower one to 0.4. At energies less than the SPS-collider ones the uncertainties of all parameters compensate each other and the error corridor is therefore very small; with increasing energy it begins to extend rapidly. For precise fixation of all parameters the experiments on slope measurement are necessary, at least at one more energy value of the order of $\xi \approx 20$. The error corridor presented in all the rest figures is due mainly to uncertainty in $\alpha'_P(0)$. A similar corridor exists also in the theory with supercritical pomeron where $\alpha'_P(0) = 0.25 \pm 0.1$ (GeV/c)$^{-2}$, but we won't show it in the figures lest the drawings should be overloaded.

The diffraction cone slopes in the RCP theory grow very quickly exceeding considerably the froissaron theory slopes which come out to asymptotics $\sim \xi^2$ only at energies $\xi > 30$. The asymptotic rate of the slope growth in RCP is $\sim \xi^{1,139}$ being reached already at $\xi > 15$.

c) The Ratio $\rho = Re\, M(\xi,0)/Im\, M(\xi,0)$.

Fig.3 presents the ratio of real to imaginary parts of the pp-scattering amplitude at t = 0. As shown in Ref. [29] , at high energies the relation

$$\rho(\xi) = \frac{\mathrm{Re}\, M(\xi,0)}{\mathrm{Im}\, M(\xi,0)} \underset{s\to\infty}{\approx} \frac{1}{\sigma^{tot}(\xi)} \frac{\pi}{2} \frac{d}{d\xi} \sigma^{tot}(\xi) . \qquad (12)$$

is valid. At $t \neq 0$ it was shown in [29] and [30] that at high energies the relation

$$\mathrm{Re}\, M(s,t) = \mathrm{Re}\, M(\xi,0) \frac{d}{dt} (t\, \mathrm{Im}\, M(\xi,t)) . \qquad (13)$$

must take place. At $E \lesssim 1000$ GeV the perturbation theory formulae were used, in which $\mathrm{Re}\, M(\xi,t)$ was calculated directly from signature multipliers. Thus obtained $\mathrm{Re}\, M(\xi,t)$ agrees well in this region with the results obtained from formulae (12) and (13) and describes well the experimental data.

At SPS-collider energy the RFT gives $\rho = 0.136$, while froissaron $\rho = 0.134$. On asymptotics both theories give a decrease $\rho \sim \frac{1}{\xi}$ . However the curve corresponding to froissaron lies considerably higher than the RCP one.

d) Elastic Cross Section $\sigma^{el}(\xi)$.

Fig.4 presents the elastic cross section of pp-interaction. In RCP model it was calculated in the form of the integral over t from $d\sigma/dt$ obtained in Ref. [4] . The agreement with existing experimental data is good at all energies. The error corridor is due to uncertainty in the quantity $\alpha'_p(0)$ .

The elastic cross section in the supercritical pomeron model was calculated by formula (9). The agreement with the experiment here is much worse.

In RFT this cross section turned out larger than the one obtained from approximate relation

$$\sigma^{el}(\xi) \approx (1+\rho^2)\sigma_{tot}^2 / 16\pi B(\xi), \qquad (14)$$

which points out an essential contribution of region of large transferred momenta.

At SPS-collider energy the experiment gives the value $\sigma^{el}$=13.31±0.63 mb. In the RCP theory we obtain $\sigma^{el}$ = 13.19 mb, while in the froissaron one $\sigma^{el}$ = 9.73 + 11.9 mb. The behaviour of $\sigma^{el}$ in these theories is essentially different on asymptotics. In RCP it falls off as $\xi^{-0,585}$, while in froissaron it grows as $\xi^2$ and tends to its asymtotic limit $\sigma^{el} \to \frac{1}{2}\sigma^{tot}$. In RCP $\sigma^{el}$ begins to fall off at $\xi > 20$, while before that it grows as $\xi^2$.

Fig.5 presents the ratio $\sigma^{el}/\sigma^{tot}$. As was shown in Ref. [31], this quantity is crucial to clear up the question: Which of the two theories does work more correctly at superhigh energies? From (14) we have

$$\frac{\sigma^{el}}{\sigma^{tot}} \approx \frac{\sigma^{tot}(\xi)}{16\pi B(\xi)}.$$

In RCP theory at asymptotically high energies this ratio behaves as $\xi^{-0,862}$; in supercritical pomeron theory we have $\sigma^{el}/\sigma^{tot} \to \frac{1}{2}$, but at $\xi$ =30 we have only 0.235+0.26. In the region of practically accessible energies an inverse picture is observed: up to $\xi \lesssim 17$ $\sigma^{el}$ and $\sigma^{el}/\sigma^{tot}$ in RCP grow much more rapidly than in froissaron, after which RCP begins to fall off gradually, while froissaron goes on growing. Therefore the conclusion of A.Marten [31], that the value 0.215±0.005 obtained on SPS-collider which is larger than 0.18 obtained on ISR rejects the RCP theory, is incorrect. A.Marten believes that in RCP the ratio $\sigma^{el}/\sigma^{tot}$ must fall off already at $\xi > 8$; this is wrong since in this statement he does not take into account the contributions of branchings which change essentially the whole picture. Owing to their contribution this ratio begins to fall off only at $\xi > 18$. While at SPS-collider energy the RCP gives the value $\sigma^{el}/\sigma^{tot} = 0.215$, this being in striking agreement with experimental value 0.215±0.005 as distinct from the value $\sigma^{el}/\sigma^{tot} = 0.178$ given by froissaron.

e) Inelatic Cross Section

Fig.6 gives inelastic cross sections of pp-scattering for RCP and froissaron; they were calculated by the formula

$$\sigma^{in}(\xi) = \sigma^{tot}(\xi) - \sigma^{el}(\xi). \tag{15}$$

One can see that both models agree well to each other and to experimental data.

On the collider the value $\sigma^{in} = 48.6 \pm 2.1$ mb was obtained. In RCP $\sigma^{in} = 48.16$ mb, and in froissaron $\sigma^{in} = 46.75 \div 50.47$ mb. On the asymptotics in RCP $\sigma^{in} \sim \xi^{0,277}$, while in froissaron $\sigma^{in} \sim \xi^{2}$

f) The Ratio $C(\xi) = \frac{\sqrt{s}}{2P}\,\frac{4\pi B(\xi)}{\sigma^{tot}(\xi)}$.

Fig.7 presents the ratio

$$C(\xi) = \frac{\sqrt{s}}{2P}\,\frac{4\pi B(\xi)}{\sigma^{tot}(\xi)}. \tag{16}$$

A.B.Kaidalov has shown in [32] that the shower amplification coefficient (7) is connected with total cross section and slope by relation (16) which must be valid in the region of medium and high energies. At non-superhigh energies this leads to a simple geometrical picture of scattering on particle as on "grey" ball of radius $R \sim 1/\sqrt{B(\xi)}$, and what is more essential, its "grey color" is unambiguously determined by quantity $C(\xi)$.

One can see from the figure that at medium energies $C(\xi)$ is a constant and $C \approx 1.5$, which agrees well with formulae (7) and (8) for the model with froissaron. However at SPS-collider energies we have $C = 1.203 \pm 0.016$, this obviously contradicting (8). Hereafter one can conclude that in the supercritical pomeron theory the shower amplification coefficient must be a function of energy and have the form shown in Fig.7. This is apparently one of the simplest ways to improve the froissaron model for a better agreement with experimental data.

In RCP theory for this ratio at collider energy we have 1.255, while in froissaron 1.223 ÷ 1.406. On asymptotics in RCP this ratio grows as $\xi^{0,862}$, while in froissaron it tends to 1/2 and can therefore serve as a test for the choice of theory.

g) Partial Amplitude in Impact Parameter Representation $f(\xi, b)$.

In order to make clear what is the main difference between both models, let us consider the partial amplitude $f(\xi, b)$ in the representation of the impact parameter $b$, which is defined from the following condition:

$$M(\xi,t) = \int e^{i\vec{k}\vec{b}} f(\xi,b)\frac{d^2 b}{2\pi} \tag{17}$$

In the supercritical pomeron theory in the usual quasi-eikonal model $f(\xi,b)$ has a very simple form:

$$f(\xi,b) = \frac{1}{2ic}\left(e^{c\chi(b,\xi)} - 1\right); \tag{18}$$

where $\chi(b,\xi)$ is the pole eikonal

$$\chi(b,\xi) = -\frac{z}{2C} e^{-\frac{b^2}{4\lambda_P}}$$

In the RCP model, using the method of exact summation of quasi-eikonal series we have

$$[\hat{f}(b,\xi)]_{11} = [\frac{1}{2i}\sum_{n=1}^{\infty}\frac{\hat{\chi}^n}{n!}]_{11} = \frac{1}{2i}(e^{\hat{\chi}}-1)_{11} \quad , \tag{19}$$

where $\hat{f}$ and $\hat{\chi}$ are 4x4 matrices, and indices 11 denote that one should take element 11 of matrix $\hat{f}$ . We won't write out here the exact form of $\hat{f}$ and $\hat{\chi}$ for they are rather cumbersome.

The results obtained for $f(\xi,b)$ are given in Fig.8 as functions of $\xi$ at $b$ = 0; 5 and 10 GeV$^{-2}$.

At the top of the figure there are given the values of $f(b,\xi)$ at $b$ = 0, which corresponds to "non-transparency" of the nucleon central part. In froissaron the "non-transparency" uniformly grows with increasing energy and reaches its limiting value equal to 1/2C at $\xi \approx 30$. This corresponds to scattering on a ball with constant "grey color" $\sim$ 1/C. In RCP the situation is much more complicated: at low energies the central part of the nucleon rapidly "turns grey" and achieves its most "transparent" value at $\xi \approx 8$; at further energy increase the centre begins to "darken" rapidly and achieves its "blackest" value at $\xi \approx 16$; then again begins "lightening" and $f(0,\xi)$ reaches its asymptotical regime typical for RCP-scattering on a "grey" ball whose "transparency" grows with increasing energy, but the radius grows even more rapidly. The "transparency" grows as $\xi^{0,862}$ , and squared radius grows as $\xi^{1,139}$ , therefore total cross sections on asymptotics grow as $\xi^{0,277}$ . In the whole energy region $f(0,\xi)$ in RCP behaves as $C^{-1}$ determined in formula (16). This points out that the method of quasi-eikonal series exact summation is equivalent to the account of shower amplification coefficients as functions of $\xi$ .

At the bottom of the figure $f(b,\xi)$ at $b = 5$ and 10 are shown. One can see that with increasing energy the interaction radius grows more rapidly in RCP than in froissaron; yet at very high energies froissaron outruns RCP. One can say that at asymptotically high energies RCP corresponds to scattering on a ball with smeared edges which "turns grey" rapidly with increasing energy, but its radius grows even more rapidly.

Froissaron in the whole energy range corresponds to scattering on a "grey" ball which rapidly "blackens" and achieves some permanent "grey color" at $\xi > 30$. Its radius grows firstly relatively slowly, but at asymptotic energies it grows as $\xi^2$ . The whole scattering pattern then looks as scattering on a ball with constant "grey color" having sharp edges with a radius increasing as $\xi^2$ , this just leading to saturation of froissar's limit.

5. Comparison with Hadron-Nuclei Interaction Experiment.

Fig.9 presents theoretical curves describing $\sigma_{p-air}^{prod}$ in both theories considered. Experimental data are taken from Refs [8-10, 33] . The solid curve refers to renormgroup critical pomeron. The upper dash-dotted curve refers to supercritical pomeron with parameter set (8a), the lower one - with parameters (8). One can see that up to $\xi \gtrsim 25$ both theories describe the existing experimental material rather well and practically coincide to each other. Both critical and supercritical (with parameter set (8a)) pomerons pass through the FIAN points [16,33] , along the lower edge of FUJI corridor, through the middle of Akeno corridor and directly through the "Fly's Eye" point. At $\xi > 16$ froissaron begins to exceed the cross section given by RCP.

Note one interesting circumstance: Fig.1 presents $\sigma_{pp}^{tot}$ for both models; the predictions of the froissaron theory there achieve and exceed the corresponding predictions of the RCP theory already at $\xi > 16$. As to the scattering on the air nuclei, the curve corresponding to froissaron is systematically lower in the whole interval $15 < \xi < 25$. This is due to the fact that though total cross sections in froissaron at $\xi > 16$ lie higher, the slopes $B(\xi)$ lie considerably below the slopes in RCP. In what follows we shall explain this phenomenon at greater length.

Figs 10 and 11 present total cross sections of pp-interaction in theories with critical pomeron and froissaron (with a set of (8a) parameters), respectively. Ibidem are given results of extraction of pp cross sections from experimental data on photon-nuclei interaction on the air nuclei at cosmic energies. These results are obtained using the method described in Sect. 3. Circles with arrows denote those values of extracted points which lie above the unitary limit for the given theory. One can see from the figures that both theories agree with those marked points equally well. At the same time it is clear that the cosmic-ray experiments require a more rapid growth of the diffraction cone slopes than one the both theories are able to give. The theory with RCP in this respect looks as a more preferable one.

Figs 12 and 13 present the diffraction cone slopes in theories with critical pomeron and froissaron (with (8a) parameter set), respectively. The experimental data given in these figures are conventional, but they are helpful to understand the general tendency of the slopes growth. These data were extracted as follows: it was assumed that the pp-scattering total cross sections have exactly the values given by the theory; using these values by means of the above-given scheme, the corresponding values of slopes were extracted. Thus obtained slopes are just given in Figs 12 and 13 in the form of experimental data. It is seen from the figures that the required growth of slopes must be much more rapid than that given by both theories; however slopes in the critical pomeron theory satisfy the cosmic experiments requirements much better.

Fig.14 presents the partial amplitude $f(B,\xi)$ in the representation of impact parameter $B$ at $B = 0; 10; 15$ and $20\ GeV^{-2}$, as a function of $\xi$, being obtained on the basis of expression (10). The solid curve refers to the theory with renormgroup critical pomeron, while the dash-dotted one - to supercritical pomeron with a set of parameters (8).

An attentive study of this figure together with Fig.8 exhaustingly explains the result that a small difference between both theories in case of pp-scattering induces some discrepancy between them in case of scattering on nuclei.

In case of scattering on proton, at $B=0$ in RCP we had a rather complicated twisting curve which at $\xi > 16$ fell off as $\xi^{-0,862}$, what corresponds to rapid growth of transparency of the nucleon centre. At scattering on the air nucleus we observe a smoothly growing curve which already at $\xi = 15$ achieves a limit of absolutely black ball. The same form has the curve for theory with supercritical pomeron. However in theory with RCP a very slow "greying" of the nucleus central part begins after $\xi > 30$. The rapid blackening of the nucleus centre in RCP is explained by the fact that radii of nucleons that constitute the nucleus grow very rapidly with increasing energy and despite the fact that each individual nucleon "turns grey" relatively rapidly, nevertheless the nucleus centre remains constantly black in a wide energy range $15 < \xi < 45$. Hence at scattering on nucleus the contribution from the nucleus central part to the cross section will be the same in the whole range in both theories.

Consider now the other values of the impact parameter. It is seen from the figure that the nucleus radius in RCP grows much more rapidly than in froissaron, but the peripheral part of the nucleus in RCP at $\xi > 25$ is much more transparent than in theory with supercritical pomeron. Therefore at $\xi < 25$ the total cross sections in RCP on the air nuclei will be larger than the cross sections with froissaron. However at $\xi > 25$ the nucleus radius in froissaron begins to grow as $\xi^2$; this latter together with constant "blackness" of the nucleus central part provide a more rapid growth of nuclear cross sections in theory with froissaron at $\xi > 25$. The account of corrections connected with inelastic channels does not change, in principle, the train of our arguments.

From all this consideration one may conclude that the rapid growth of cross sections on nucleus in theory with RCP up to $\xi < 35$ is due to the fact that slopes in RCP grow much more rapidly than total cross sections. $\sigma_{pp}^{tot} \sim \xi^{0,277}$, while $B(\xi) \sim \xi^{1,139}$ .

In theory with supercritical pomeron the picture is inverse. One can see from formulae (4) and (9) that total cross sections in this theory will always grow with outstripping of the slopes growth. Though both $\sigma_{pp}^{tot}$ and $B(\xi)$ on asymptotics behave as $\xi^2$ , this regime for $\sigma_{pp}^{tot}$ will begin always sooner. This is an inherent property of theory with supercritical pomeron, which cannot be changed by any theoretical tricks.

## 6. Possibilities of the Models Improvement.

Both models have some reserves to improve and vary their pre-asymptotical behaviour in the range of practically accessible energies $10 < \xi < 25$.

Consider first the possibilities for RCP. First of all the values of vertices of nucleon diffraction dissociation as well as the values of vertices of mass non-diagonal transfers should be verified for they are necessary for exact summation of quasi-eikonal series. For the present work these vertices were taken from Ref.[13] in which they were apparently underestimated. If they turn out larger, this will allow still more to increase $g^2$, which will result in essential enhancement of growth rate for all elastic scattering characteristics and postpone RCP from asymptotic regime. Besides, functions $\alpha(\xi)$ and $F_2(\xi,x)$ determining t-dependence of amplitude need verification. Their exact calculation will allow one to improve essentially the description of $d\sigma/dt$ and $\sigma^{el}$ in the RCP model.

The supercritical pomeron model also has many possibilities for being improved. First, one should take into account the energy dependence of the shower amplification coefficient $C$. Second, the account of correct t-behaviour of residue functions will help to describe the pre-asymptotic region more correctly.

In the model with supercritical pomeron one should take into account also contributions from enhanced diagrams which can change substantially pre-asymptotic behaviour of theory.

Let us consider what experiments on future accelerators (SSC, LHC) could be critical for the choice of correct theory. Colliders with energy $\sqrt{s} \sim 20$ and 40 TeV ($\xi$ = 19.8 and 21.2) will appear in the nearest future. The table lists the values of interaction characteristics for both theories at the energies of $\sqrt{s}$ = 30, 52, 62, 100, 250, 550, 2000, 5000, 10000, 20000, 30000 and 40000 GeV.

Measured at 20 and 40 TeV $\sigma^{tot}$ and $b(\xi)$ most probably will not be able to set up differences between the theories; however they will allow to determine their parameters more precisely as well as remove large error corridors in the predictions. Measurements of $\sigma^{el}$ and $\sigma^{el}/\sigma^{tot}$ will already allow one to draw some conclusions. If $\sigma^{el}$ and $\sigma^{el}/\sigma^{tot}$ turn out to grow considerably slower than $\xi^2$, it will become a strong argument in favour of RCP theory. If it turns out that yet they grow rapidly.

then again the question will remain open, since some improvement of RFT will allow to achieve such a growth.

Summarizing all stated above, one can say that even at such energies one will apparently fail to find a reliable answer to the quesion: "What theory does work after all at superhigh energies?"

In conclusion the authors would like to express their sincere gratitude to A.Ts.Amatuni, S.G.Matinyan and E.A.Mamidjanyan for their support and permanent interest in the work, and also to K.A.Ter-Martirossyan, A.B.Kaidalov, A.P.Garyaka and A.E.Nazaryan for the useful discussions.

Table

| $\sqrt{s}$ GeV | $\xi$ | $\sigma^{tot}$ | $B$ | $\rho$ | $\sigma^{el}$ | $\sigma^{el}/\sigma^{tot}$ | $\sigma^{in}$ | $C$ |
|---|---|---|---|---|---|---|---|---|
| 30 | 6.8 | 40.24 | 12.11 | 0.0375 | [illegible].377 | 0.1833 | 32.86 | 1.477 |
| | | - | - | - | - | - | - | - |
| 52 | 7.9 | 42.51 | 12.73 | 0.0518 | 7.816 | 0.1839 | 34.69 | 1.469 |
| | | - | - | - | - | - | - | - |
| 62 | 8.25 | 43.32 | 12.96 | 0.0611 | 7.974 | 0.1840 | 35.35 | 1.467 |
| | | 42.55 | 12.42 | - | 7.037 | 0.1654 | 35.51 | 1.431 |
| 100 | 9.21 | 46.03 | 13.59 | 0.0893 | 8.581 | 0.1864 | 37.45 | 1.448 |
| | | 46.53 | 13.08 | - | 7.965 | 0.1712 | 38.57 | 1.378 |
| 250 | 11.04 | 53.53 | 14.77 | 0.128 | 10.678 | 0.1995 | 42.85 | 1.352 |
| | | 54.94 | 14.43 | - | 10.017 | 0.1823 | 44.93 | 1.287 |
| 550 | 12.62 | 62.05 | 15.80 | 0.136 | 13.412 | 0.2162 | 48.64 | 1.248 |
| | | 63.03 | 15.67 | 0.134 | 12.083 | 0.1917 | 50.95 | 1.219 |
| 1000 | 13.82 | 69.22 | 17.38 | 0.129 | 15.176 | 0.2192 | 54.05 | 1.230 |
| | | 69.70 | 16.67 | 0.130 | 13.841 | 0.1986 | 55.86 | 1.172 |
| 2000 | 15.20 | 77.62 | 19.45 | 0.112 | 17.045 | 0.2196 | 60.57 | 1.228 |
| | | 78.02 | 17.90 | 0.125 | 16.092 | 0.2063 | 61.93 | 1.124 |
| 5000 | 17.03 | 87.81 | 23.03 | 0.0852 | 18.424 | 0.2098 | 69.39 | 1.286 |
| | | 89.97 | 19.64 | 0.119 | 19.412 | 0.2158 | 70.56 | 1.070 |
| 10000 | 18.42 | 94.35 | 26.20 | 0.0666 | 18.706 | 0.1982 | 75.66 | 1.361 |
| | | 99.73 | 21.05 | 0.114 | 22.176 | 0.2220 | 77.55 | 1.035 |
| 20000 | 19.81 | 99.83 | 28.90 | 0.0515 | 18.982 | 0.1901 | 80.85 | 1.419 |
| | | [illegible] | 22.56 | 0.110 | 25.158 | 0.2280 | 84.94 | 1.004 |
| 30000 | 20.62 | 102.57 | 30.33 | 0.0445 | 19.091 | 0.1861 | 83.48 | 1.449 |
| | | 116.45 | [illegible] | 0.107 | 27.000 | 0.2318 | 89.45 | 0.988 |
| 40000 | 21.19 | 105.02 | [illegible] | 0.0402 | 19.131 | 0.1834 | 85.20 | 1.471 |
| | | 118.92 | [illegible] | 0.106 | 27.716 | 0.2331 | 91.20 | 0.982 |

In each line the upper numbers refer to RCP, the lower ones - to froissaron.

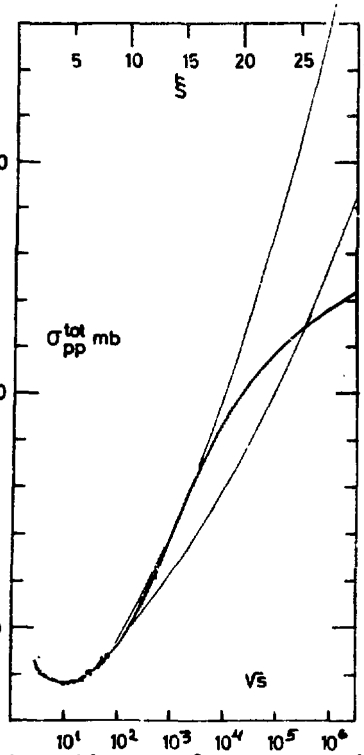


Fig.1. pp-interaction total cross sections $\sigma^{tot}(\xi)$

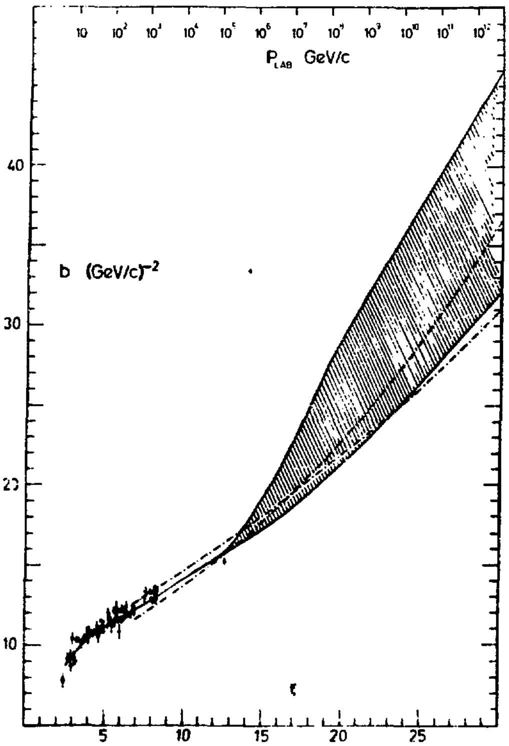


Fig.2. The slopes of the diffraction cone $b(\xi)$ at $-t < 0.1$.

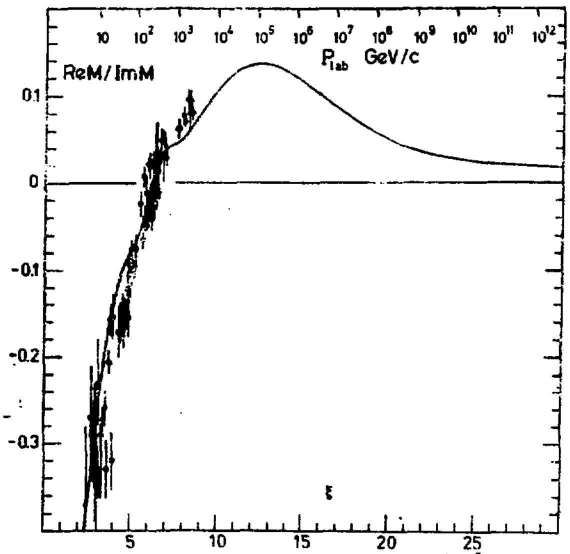


Fig.3. The ratio $\rho = ReM(\xi,0)/ImM(\xi,0)$.

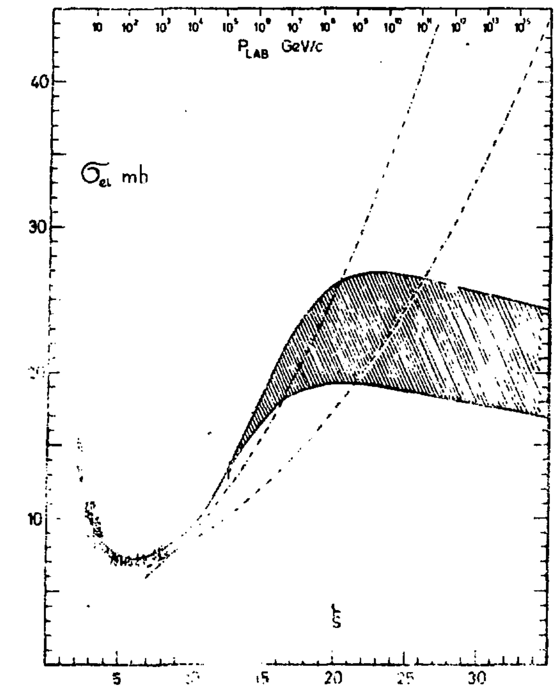


Fig.4. Elastic interaction cross sections $\sigma^{el}(\xi)$

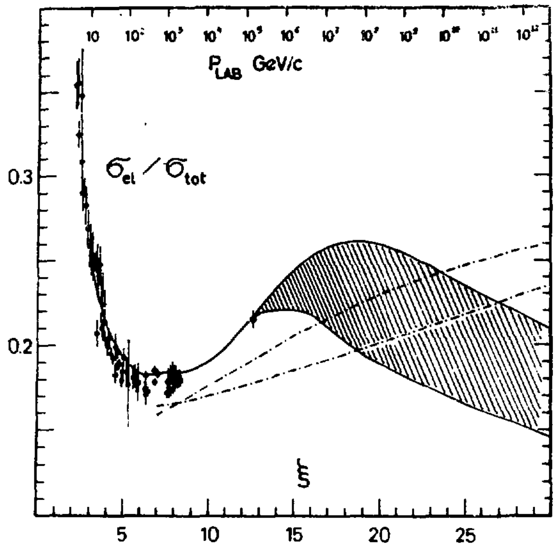


Fig.5. The ratio $\sigma^{el}(\xi)/\sigma^{tot}(\xi)$

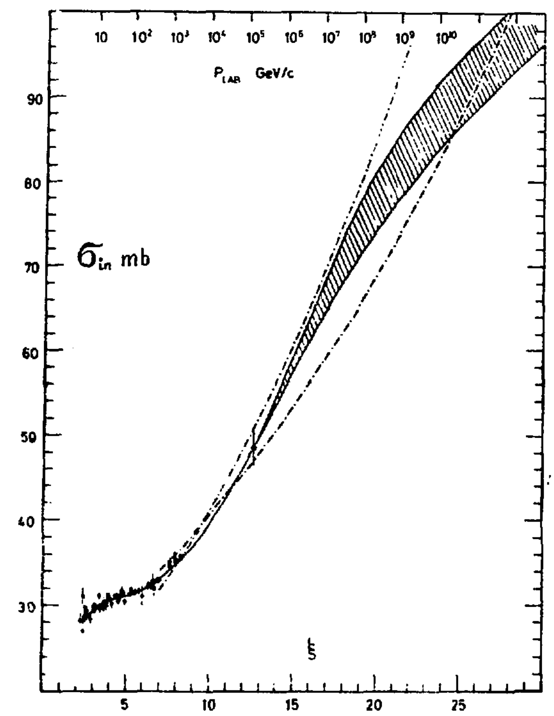


Fig.6. Inelastic interaction cross sections $\sigma^{in}(\xi)$

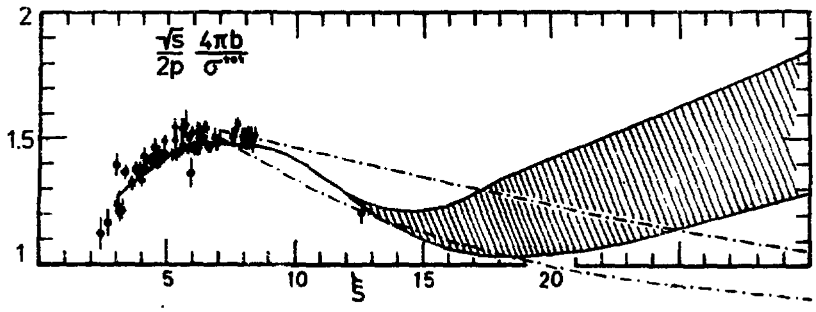


Fig.7. The ratio $C(\xi) = \frac{\sqrt{s}}{2P}\ \frac{4\pi B(\xi)}{\sigma^{tot}(\xi)}$

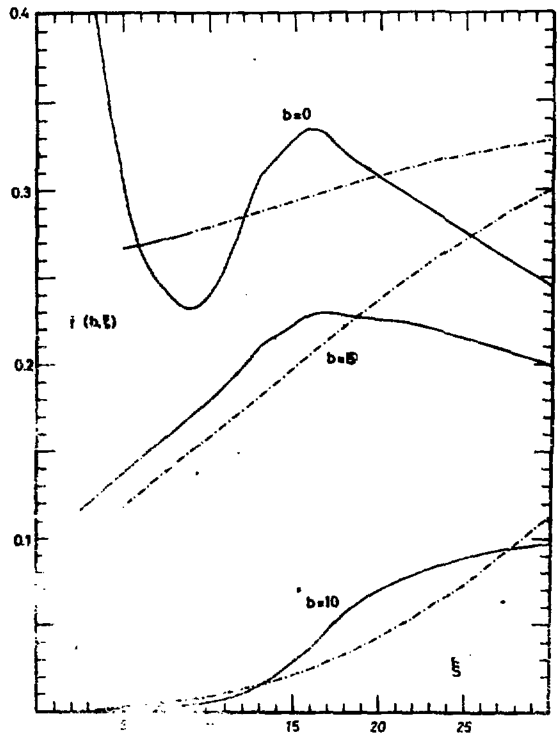


Fig.8. Partial amplitude in the impact parameter representation

$f(\xi, B)$

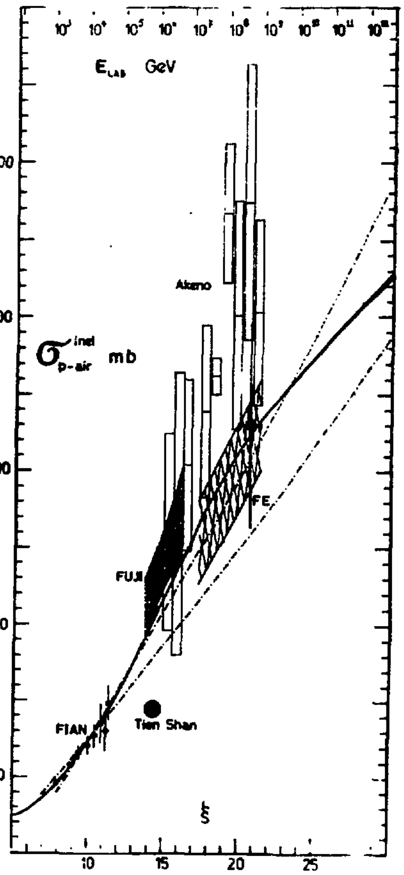


Fig.9. Production cross sections on atomic nuclei $\sigma_{p\text{-air}}^{prod}$ in theories with critical and supercritical pomerons.

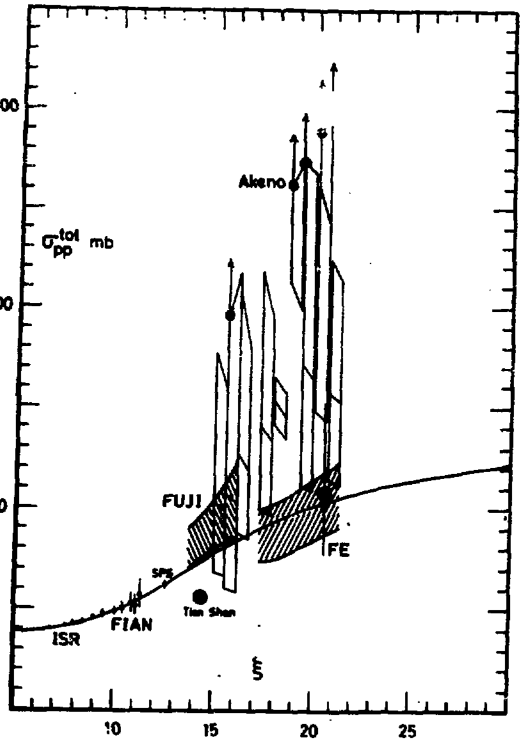


Fig.10. pp-scattering total cross section in theory with critical pomeron.

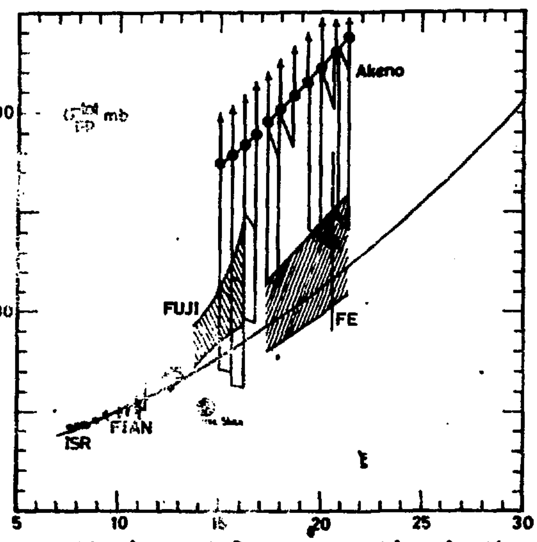


Fig.11. pp-scattering total cross section in theory with supercritical pomeron.

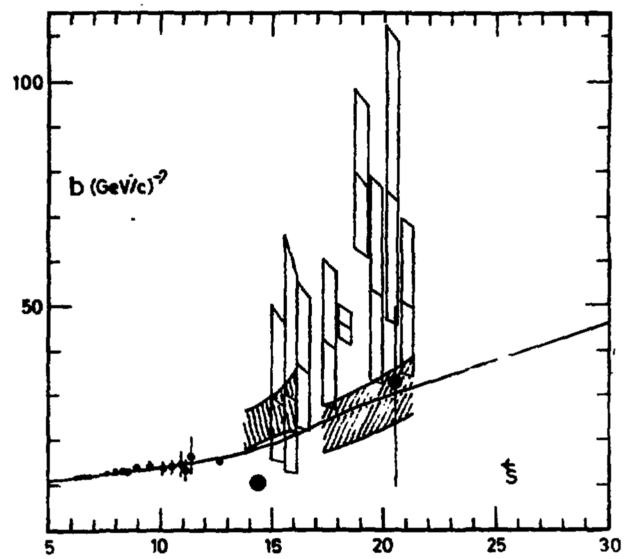


Fig.12. The slope of pp-scattering diffraction cone in theory with critical pomeron.

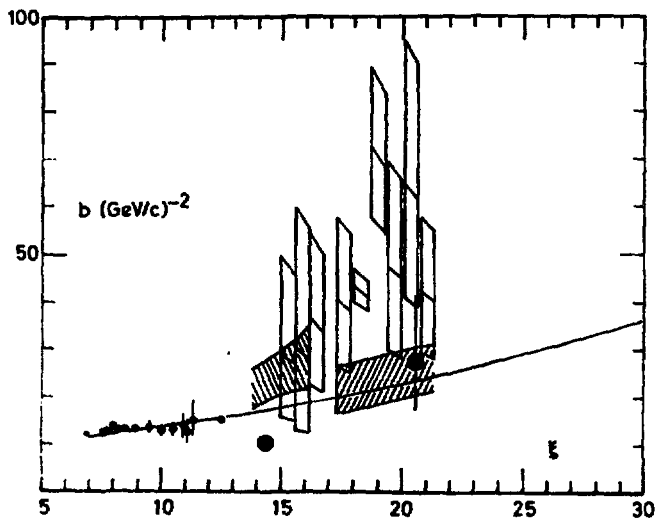


Fig.13. The slope of pp-scattering diffraction cone in theory with supercritical pomeron.

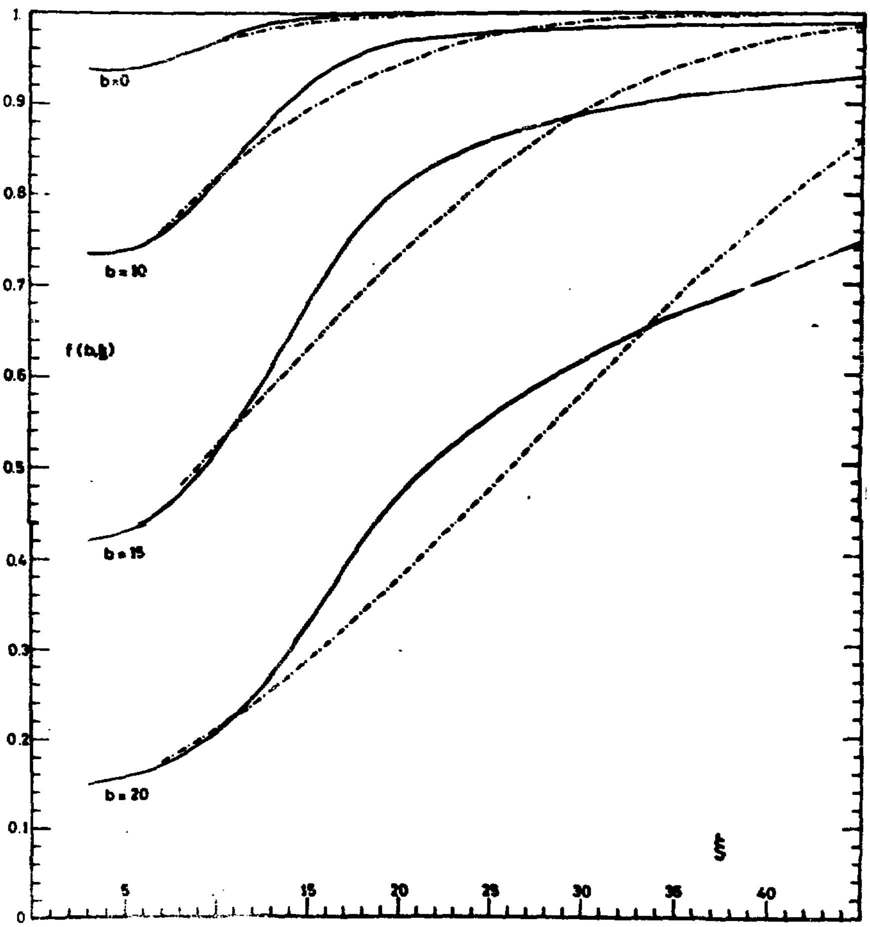


Fig.14. Partial amplitude $f(B,\xi)$ of proton-nuclei interaction in the impact parameter B representation.

## REFERENCES


1. Еремян Ш.С., Назарян А.Э. Реджеонная теория поля при $\mathcal{D}=2$ в двухпетлевом приближении. ЯФ,1983, т.37, вып.3, с.727-746.
2. Еремян Ш.С., Жамкочян В.М. Адрон-адронные и адрон-ядерные взаимодействия при сверхвысоких энергиях в теории критического померона. ЯФ, 1984, т.40, вып.4(10), с.1016-1023.
3. Еремян Ш.С., Жамкочян В.М. Реджеонная теория возмущений и критический ренормгрупповой померон в адрон-адронных и адрон-ядерных взаимодействиях при сверхвысоких энергиях. ВАНТ, серия ТФЭ, 1983, вып.5(17), с.49-57.
4. Еремян Ш.С., Назарян А.Э. Дифференциальные сечения $pp$ - рассеяния при сверхвысоких энергиях в теории критического померона. ЕФИ-752(67)-84, Ереван,1984.
5. Волковицкий П.Э., Лапидус А.М., Лисин В.И., Тер-Мартиросян К.А. Описание данных опыта в теории померона с $\alpha_P(0)>1$ и некоторые ее следствия. ЯФ, 1976, т.24, вып.6, с.1237-1249.
6. Кайдалов А.Б., Тер-Мартиросян К.А. Множественное образование адронов при высоких энергиях в модели кварк-глюонных струн. Теория. ЯФ, 1984, т.39, вып.6, с.1545-1558.
7. Кайдалов А.Б., Тер-Мартиросян К.А. Множественное рождение адронов при высоких энергиях в модели кварк-глюонных струн. Сравнение с экспериментом ЯФ, 1984, т.40, вып.1(7), с.211-220.

8. Rao M.V.S., Subramanian A. Cosmic Rays at Bangalore. - CERN Courier, 1984, v.24, No.2, p.58-61.

9. Baltrusaitis R.M., Cassiday G.L., Elbert J.W. et al. Total Proton-Proton Cross Section at $\sqrt{s}$ = 30 TeV. - Phys.Rev.Lett., 1984, v.52, No.6, p.1380-1383.

10. Hara T., Hatano Y., Hayashida N. et al. Inelastic p-Air Cross Section at Energies between $10^{16}$ and $10^{18}$ eV Estimated from Air-Shower Experiments.- Phys.Rev.Lett., 1983, v.50, No.26, p.2058-2060.

II. Мигдал А.А., Поляков А.М., Тер-Мартиросян К.А. Теория взаимодействующих померонов и адронные реакции при высокой энергии. В кн."Проблемы ядерной физики элементарных частиц". М.: Наука, 1975, с.147-184.

I2. Еремян Ш.С., Назарян А.Э. О перенормируемости реджеонной теории поля с учетом порогов и "массовых" членов при $\mathcal{D}$ =2. ЯФ, 1982, т.36, вып.6(I2), с.1495-1503.

I3. Еремян Ш.С. Дифракционное рассеяние и зависимость коэффициентов ливневого усиления от энергии и переданного импульса. ЯФ, 1978, т.27, вып.I, с.259-276.

I4. Еремян Ш.С., Назарян А.Э. Точное суммирование квазиэйконального ряда. ЯФ, 197[illegible], т.28, вып.5(II), с.1408-1417.

I5. Glauber R.Y. High Energy Physics and Nuclear Structure. - New York, Plenum Press, 1970.

I6. Нам Р.А., Никольский С.Н., Старков Н.И. и др. Определение полных сечений протон-протонного взаимодействия из космических данных. ЯФ, 1977, т.26,с.1038.

I7. Бадалян А.Р., Геворкян С.Р., Жамкочян В.М., Мамиджанян Э.А. К вопросу об извлечении нуклон-нуклонных сечений из экспериментов на ядрах при сверхускорительных энергиях. ВАНТ, серия ТФЭ, 1983, вып.5(17), с.39-41.

18. Flaminio V., Moorhead W.G., Morrison D.R.O., Rivoire N. Compilation of Cross Sections. III. p and p Induced Reactions. - CERN, Geneva, 1984.

19. Burq J.P., Chemarin M., Chevallier M. et al. Soft $\pi p$ and pp Elastic Scattering in the Energy Range 30 to 345 GeV. - Nucl.Phys., 1983, v.B217, p.285-335.

20. Bartenev V., Kuznetsov A., Morozov B. et al. Measurement of the Slope of the Diffraction Peak for Elastic p-p Scattering from 8 to 400 GeV. - Phys.Rev.Lett., 1973, v.31, No.17, p.1088-1091.

21. Burq J.P., Chemarin M., Chevallier M. et al. Experimental Results on pp Forward Elastic Scattering and the Possibility of Universal Shrinkage of the Hadronic Diffraction Cone. - Phys.Lett., 1982, v.109B, No.12, p.124-128.

22. Bartenev V., Kuznetsov A., Morozov B. et al. The Real Part of the p-p Forward Scattering Amplitude from 50 to 400 GeV. - NAL-Pub-73/73- EXP 7100. 036. 1973.

23. Amaldi U., Cocconi G., Diddens A.N. et al. The Real Part of the Forward Proton-Proton Scattering Amplitude Measured at the CERN ISR. - Phys.Lett., 1977, v.66B, No.4, p.390-394.

24. Fajardo L.A., Majka R., Marx J.N. et al. Real Part of the Forward Elastic Nuclear Amplitude for pp, $\pi^{\pm}p$, $K^{\pm}p$ Scattering between 70 and 200 GeV/c. - Phys.Rev.D, 1981, v.24, No.1, p.46-65.

25. Baksay L., Baum L., Bohm A. et al. Measurements of the pp Total Cross Section and Small Angle Elastic Scattering at ISR Energies. - Nucl.Phys., 1978, v.B141, p.1-28.

26. Gross D., Jenkins E., Kuznetsov A. et al. Real Part of the pp, pd and pn Forward Scattering Amplitudes from 50 to 400 GeV. - Phys.Rev.Lett., 1974, v.41, No.4, p.217-220.

27. Amaldi U., Schubert K.R. Impact Parameter Interpretation of pp Scattering from a Critical Review of All ISR Data.- Nucl.Phys., 1980, v.B166, p.301-320.

28. Шафранова М.Г. Упругое pp -, pd - и pn - рассеяние на малые углы при высоких энергиях. ФЭЧАЯ, 1974, т.5, вып.3, с.645-692.

29. Marten A. Asymptotic Behaviour of Real Part of the Scattering Amplitude at t ≠ 0. - Lett. Nuovo Cim., 1973, v.7, series 2, No.16, p.811-812.

30. Marten A. Elastic Scattering and Total Cross Sections. - CERN 83-04, 1983, p.351-371.

31. Marten A. Elastic Scattering. - Ref. TH. 3901-CERN, 1984.

32. Кайдалов А.Б. О связи между полным сечением взаимодействия и наклоном дифракционного конуса. ЯФ, 1972, т.16, вып.2, с.389-394.

33. Нам Р.А., Никольский С.Н., Павлюченко В.П. и др. Измерение сечений неупругого взаимодействия протона с ядрами атомов воздуха при энергиях больше 1 ТэВ. В кн.Космические лучи и ядерные взаимодействия высокой энергии. Труды ФИАН. М.: Наука, 1977, т.109.

The manuscript was received 25 July 1985

Ш.С.ЕРЕМЯН, В.М.ЖАМКОЧЯН
О ПОЛНЫХ СЕЧЕНИЯХ И НАКЛОНАХ ПРИ СВЕРХВЫСОКИХ ЭНЕРГИЯХ

(на английском языке, перевод З.Н.Асланян)

Редактор Л.П.Мукаян

Технический редактор А.С.Абрамян

Подписано в печать 30/XII-85г. ВФ-09103 Формат 60x84/16
Офсетная печать.Уч.изд.л. 1,5 Тираж 299 экз.Ц.22 к
Зак.тип.№ 635 Индекс 3624

Отпечатано в Ереванском физичекском институте
Ереван 36, Маркаряна 2

индекс 3624

ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ